

The Economics of Methane Emissions in the U.S. Oil and Gas Industry

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Methane Abatement Costs in the Oil and Gas Industry

- Methods for Estimating Abatement Costs
- Evidence of Abatement Costs
- Policy Implications and Next Steps

Methane Abatement Costs in the Oil and Gas Industry: Survey and Synthesis¹

Joseph E. Aldy^a, Forest L. Reinhardt^b, and Robert N. Stavins^a

Economics of Energy & Environmental Policy, Vol. 14, No.1.

Methods for Estimating Abatement Costs

Prospective Analysis: Engineering Cost Models

- Specify equipment and actions for a “model plant”
- Estimate bottom-up cost and emission reductions
 - Investment cost plus operating cost, revenues
 - Revenues from marketing captured methane
- Prime Examples: U.S. EPA, International Energy Agency (IEA), Dunskey Climate & Energy Advisors (Dunskey)

Limitations of Engineering Models

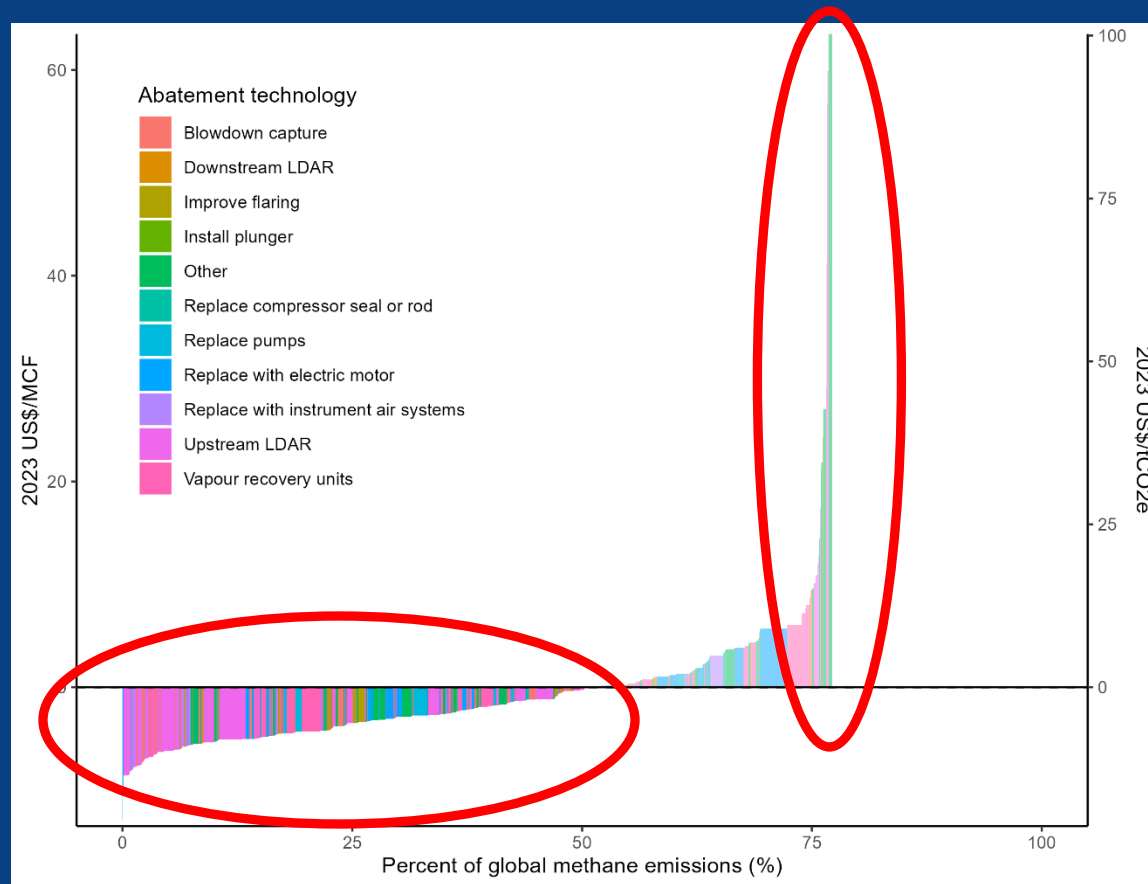
- Assume captured methane always marketable
- Often omit costs of detecting leaks before fixing
- Exclude management time/opportunity costs
- Most models build on common ICF foundation
- Average estimates mask firm-level heterogeneity

Retrospective Analysis: Econometric Models

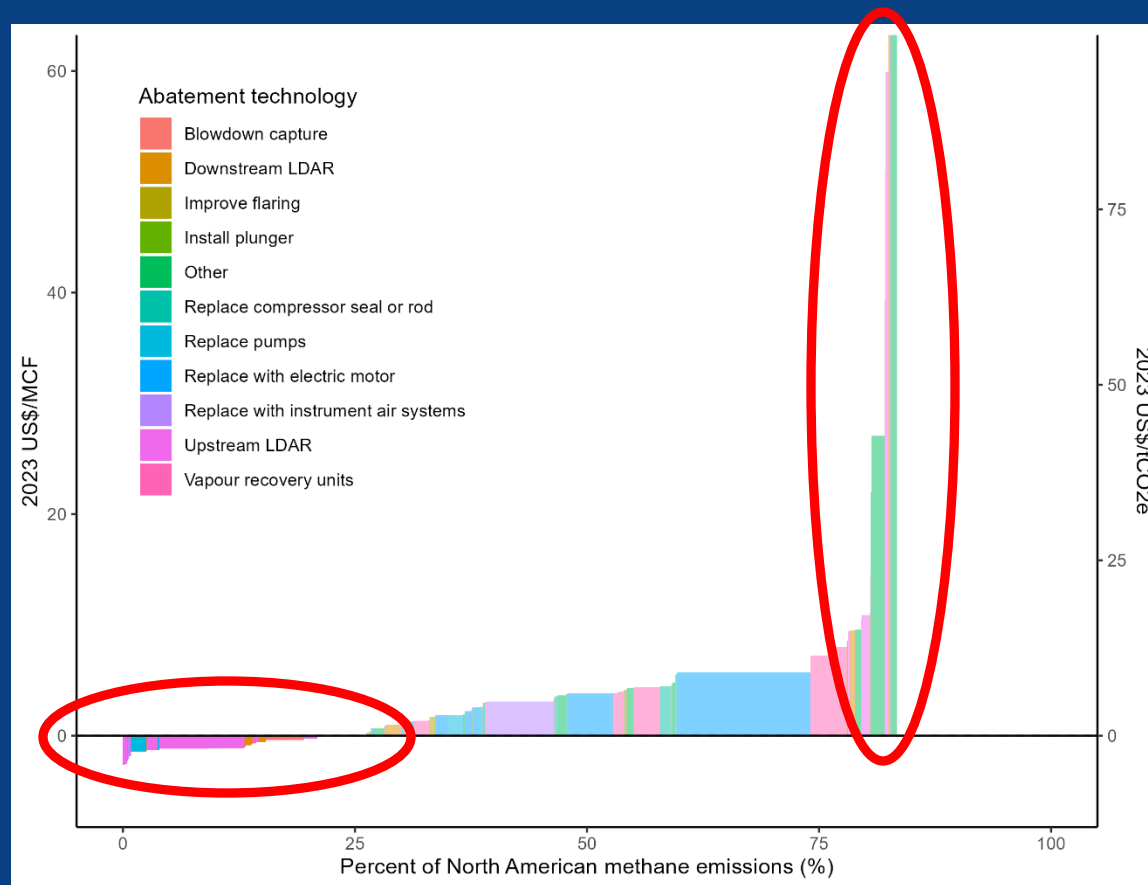
- Statistical model explaining how methane emissions vary with prices / policies
- Marks exploits variation in prices in local trading hubs and GHGRP methane data
- Lade and Rudik exploit variation in state policies
 - Couple with firm-specific engineering cost models

Evidence of Abatement Costs

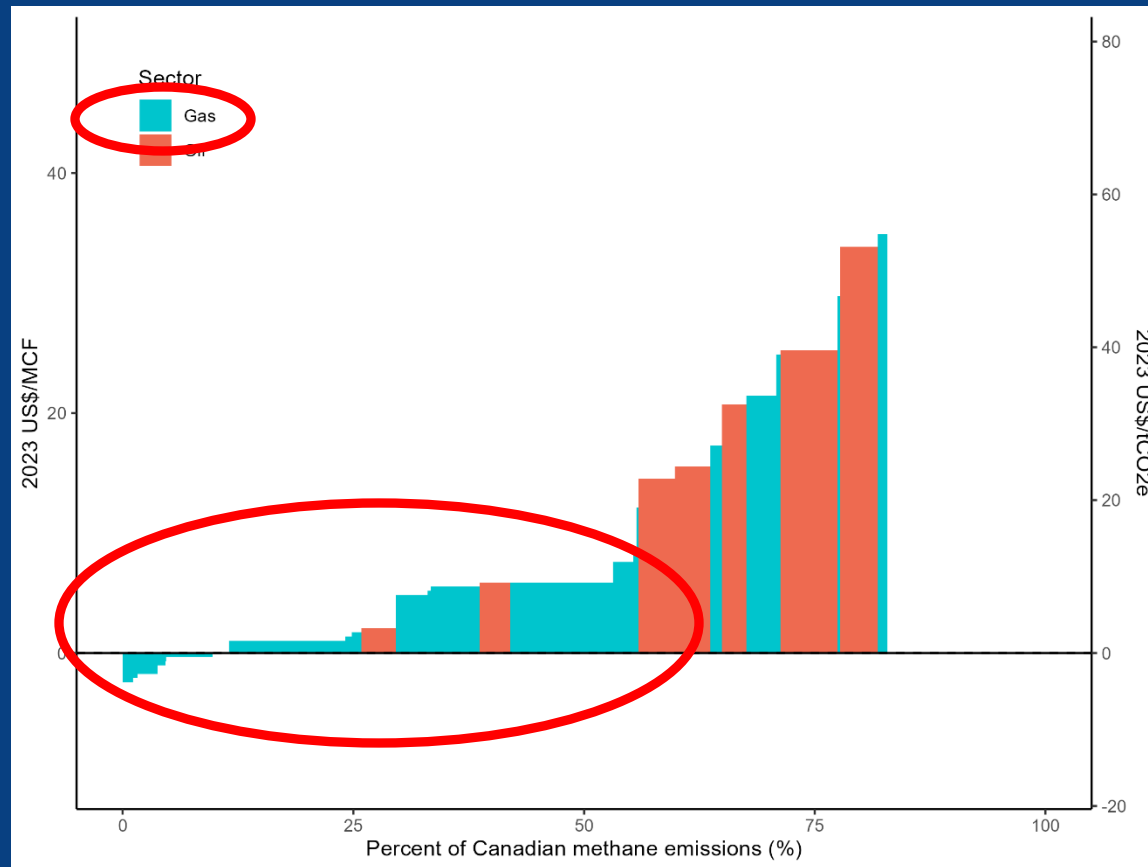
Global O&G Methane Abatement Opportunities, IEA



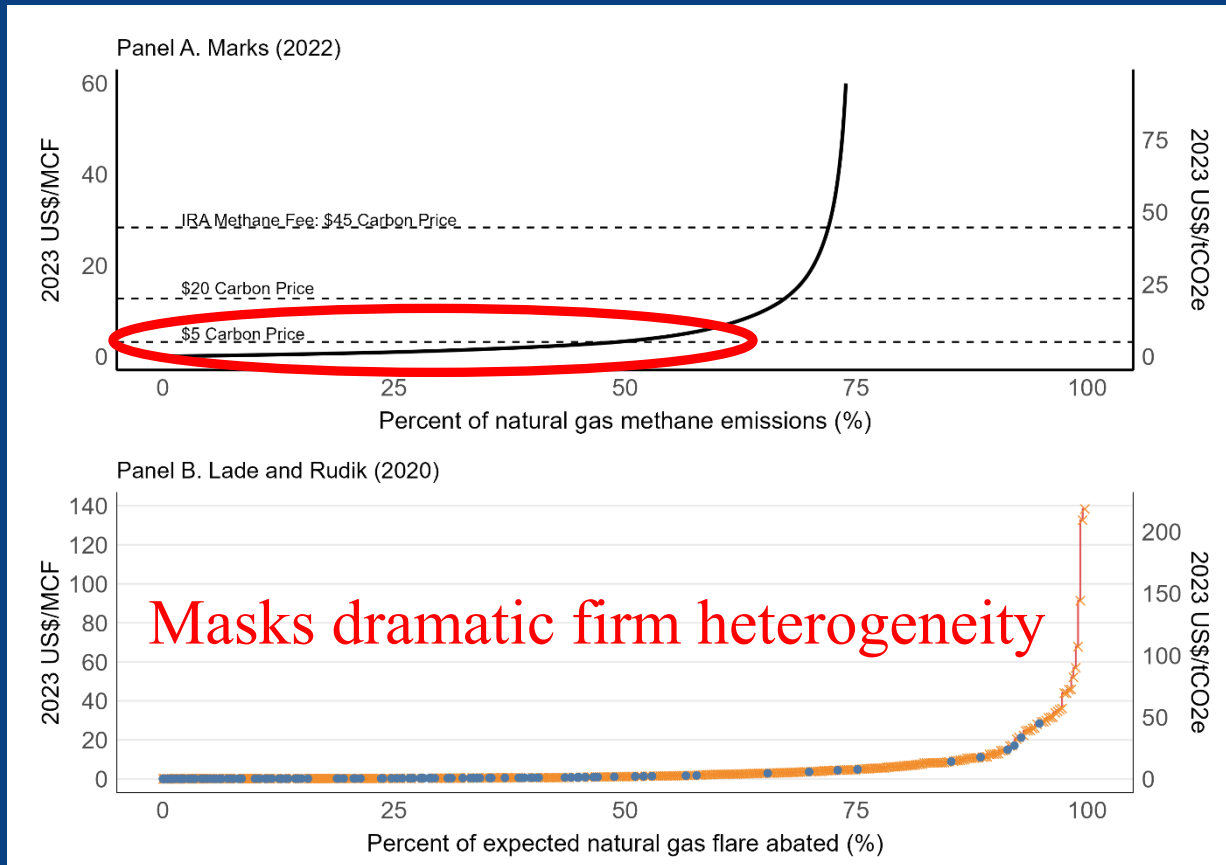
North American O&G Methane Abatement Opportunities, IEA



Canada O&G Methane Abatement Opportunities, Dunskey



U.S. O&G Methane Abatement Opportunities, Marks, Lade & Rudik



Average Abatement Costs (\$/tCO₂e)

Analysis / Model	Region	Percentage Reduction	Average Cost (\$/tCO ₂ e)
U.S. EPA	USA	80%	\$12
IEA	N. America	80%	\$11
Dunsky	Canada	80%	\$12
Marks	USA (ex CO, ND)	60%	\$6
Lade and Rudik	North Dakota	80%	\$7

Empirical Investigation of Economics of Methane Emissions

work in progress by
Joe Aldy, Rob Stavins, and Tracy Zhou

Drivers of Oil and Gas Methane Emissions

$$M_t = Q_t \times I_t$$

- Emissions can be represented by the product of:
 - quantity of production (scale), and
 - emission intensity of production (technique)
- Explore how these vary with oil and gas prices
 - Proxy for policy (e.g., methane waste fee, regulations)
 - Accounting for joint product nature of O&G

Drivers of Oil and Gas Methane Emissions

- Decompose Q_t
 - Drilling new wells more responsive to prices than producing from existing wells

$$Q_t = W_t^N q_t^N(\mathbf{p}_t) + W_t^E q_t^E(\mathbf{p}_t)$$

- W_t^i represents number of wells of type i , newly drilled or existing
- q_t^i represents production per well of type i
- $\mathbf{p}_t$ represents oil and gas prices

Drivers of Oil and Gas Methane Emissions

- Decompose I_t
 - Methane emissions vary over well life-cycle
 - Equipment and technique may vary with prices

$$I_t = I_t(f(a), p_t)$$

- $f(a)$ represents how intensity varies with well age

Drivers of Oil and Gas Methane Emissions

- Empirically evaluate various components of the drivers of O&G methane emissions

$$M_t = [W_t^N(\mathbf{p}_t)q_t^N(\mathbf{p}_t)] \times I_t^N(\mathbf{p}_t) + [W_t^E(\mathbf{p}_t)q_t^E(\mathbf{p}_t)] \times I_t^E(f(a), \mathbf{p}_t)$$

Scale

Drilling margin

Production margin

Technique

Intensity-price

Age Composition

Age emissions profile

Drilling Margin

Drilling increases in response to higher oil prices

Era:	2010–2014 (1)	2015–2019 (2)	2020–2024 (3)
<i>Variables</i>			
ln(Oil futures)	0.4240* (0.2401)	1.1140*** (0.2485)	0.9646*** (0.2185)
ln(Gas futures)	-0.3429*** (0.1177)	0.1618 (0.3141)	-0.1121* (0.0652)
<i>Fixed-effects / controls</i>			
Cell	Yes	Yes	Yes
Basin × era levels (10)	Yes	Yes	Yes
<i>Fit statistics</i>			
# Cell		312	
Observations		53,664	
Pseudo R ²		0.57600	
<i>Driscoll-Kraay (L=3) standard-errors in parentheses</i>			
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>			

Production Margin

Production does not respond to oil prices

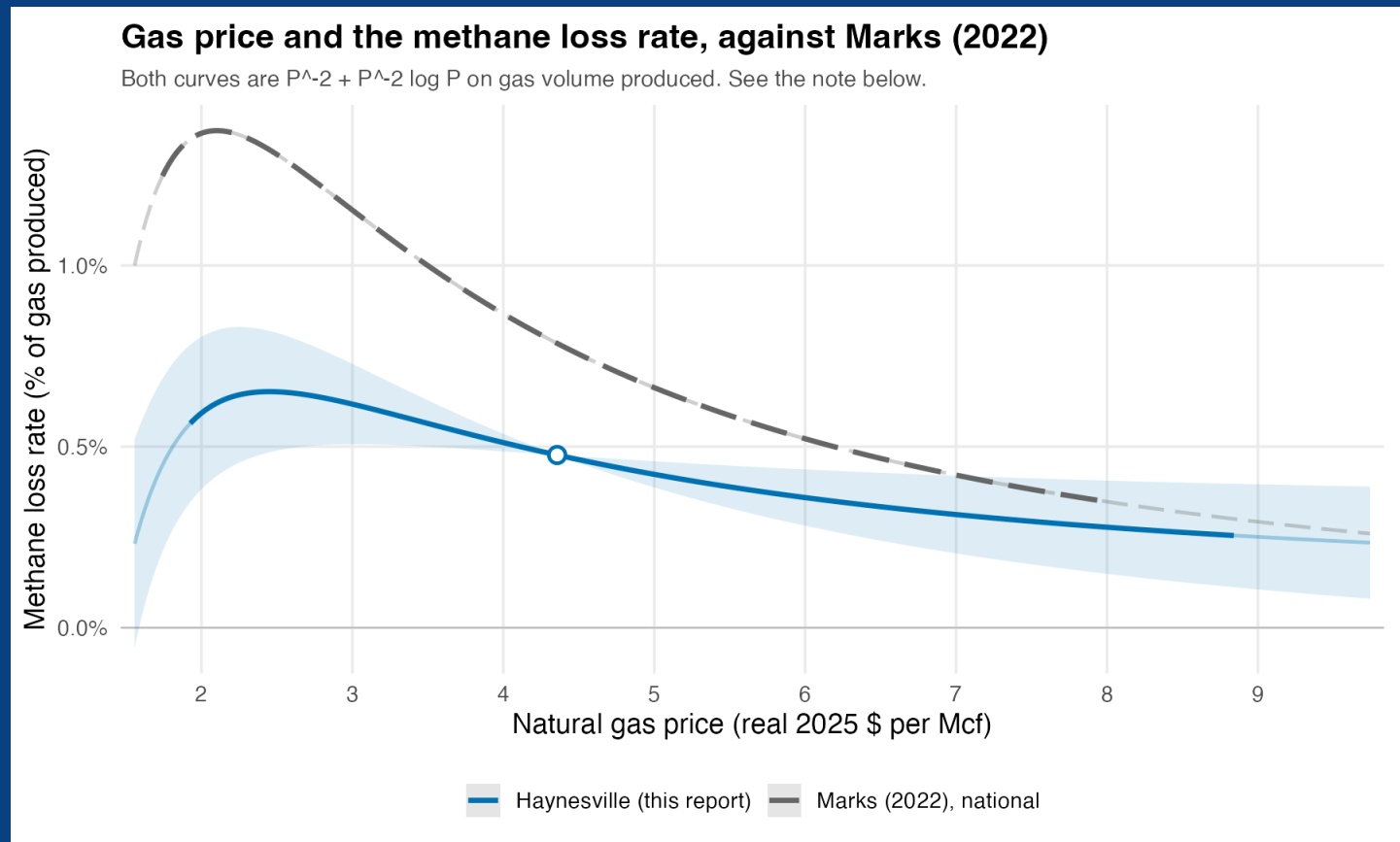
Era:	2010–2014	2015–2019	2020–2024
	(1)	(2)	(3)
<i>Variables</i>			
ln(Oil spot)	0.0126 (0.0343)	0.0353 (0.0319)	0.0438 (0.0491)
ln(Gas spot)	-0.0273 (0.0335)	-0.0205 (0.0249)	-0.0858*** (0.0238)
<i>Fixed-effects / controls</i>			
Cell	Yes	Yes	Yes
Basin $\times$ year	Yes	Yes	Yes
Calendar month	Yes	Yes	Yes
Age-bucket well counts (5)	Yes	Yes	Yes
COVID months (Mar–Jun 2020) $\times$ basin (20)	Yes	Yes	Yes
Winter Storm Uri (Feb 2021) $\times$ basin (5)	Yes	Yes	Yes
<i>Fit statistics</i>			
# Cell		327	
Observations		56,244	
Pseudo R ²		0.96834	
<i>Driscoll-Kraay (L=3) standard-errors in parentheses</i>			
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>			

Age Composition

New wells and old wells have highest emissions per well

	Basin × month (1)	Basin (2)	None (3)
<i>Well-state counts (tonnes CH₄/month per well)</i>			
Producing, <4 yr	5.6639*** (0.7953)	5.6514*** (0.7896)	6.0525*** (0.7800)
Producing, 4-15 yr	0.6793** (0.3152)	0.6914** (0.3129)	0.4070 (0.2972)
Producing, 15 yr+, ≥2 BOE/day	1.3480*** (0.3312)	1.3381*** (0.3270)	1.7983*** (0.3262)
Producing, 15 yr+, <2 BOE/day	0.3971* (0.2315)	0.4146* (0.2308)	0.4561** (0.2188)
Past last production, unplugged	-0.6124 (0.4348)	-0.6507 (0.4321)	-0.5338 (0.4202)
Past last production, plugged (P&A)	0.0175 (0.2067)	0.0239 (0.2047)	-0.0656 (0.1948)
<i>Fixed-effects</i>			
Well states in partition	6	6	6
Basin × month (120)	Yes	No	No
Basin (5)	No	Yes	No
<i>Fit statistics</i>			
Observations	8,088	8,088	8,088
R ²	0.3239	0.3026	0.2872
Within R ²	0.2734	0.2673	—
<i>Standard errors clustered by cell in parentheses</i>			
<i>Signif. Codes: ***: 0.01, **: 0.05, *: 0.1</i>			

Emission Intensity – Price Relationship



Next Steps

- Remedy data gap in Texas
- Further exploit national level data, and explore implications of state regulations, royalty policies
- Examine within-firm learning in abatement

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Reducing Global Methane
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